Supplementary Materials:
Multi-model assessment of anthropogenic influence on record warmth during 2015

Jonghun Kam[1,2], Thomas R. Knutson[1], Fanrong Zeng[1], and Andrew T. Wittenberg[1]

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[1]NOAA/Geophysical Fluid Dynamics Laboratory, Princeton, New Jersey, USA
[2] Cooperative Institute for Climate Science, Princeton University, Princeton, New Jersey

1. Uncertainties in observational data for the Niño4 region

From the HadCRUT4v3, the surface temperature anomalies for the Niño4 region are widely available since the 1950s, considering time periods with at least 33% regional coverage (Supplementary Figure 1 (a)). To extend our study period, we use two gridded sea surface temperature datasets, the ERSSTv4 and HadISSTv1.1 which are SST reconstructions back to 1856 and 1861, respectively. These datasets are generated using statistical methods and ocean models to fill missing observational data, particularly before the 1950s, which still includes critical uncertainties for the Niño4 region.

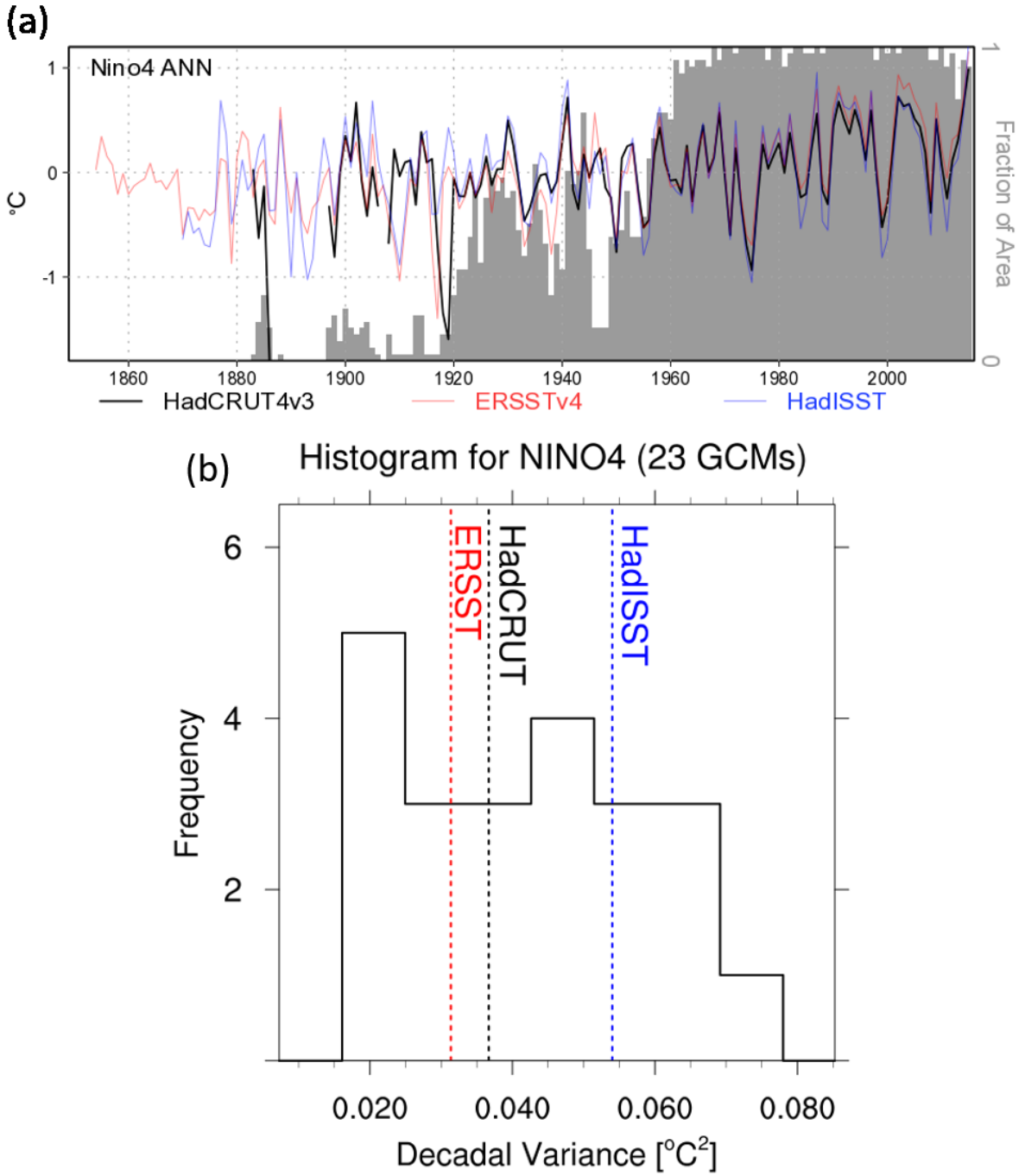
2. Histogram of the control run decadal variances from the 23 CMIP5 models with observed decadal variances

For the Niño4 region, we construct the histogram of the control run decadal variances from the 8 GCMs (bcc-csm1-1, CanESM2, CNRM-CM5, CSIRO-Mk-3-6-0, HadGEM2-ES, IPSL-CM5A-LR, IPSL-CM5A-MR, and NorESM1-M) in main text. Here, we use 23 CMIP5 models for the histogram and compute the observed decadal variances from three different surface temperature datasets (Supplementary Figure 1 (b)). For the observed decadal variances, the series are pre-filtered by subtracting the CMIP5-ALL ensemble mean anomalies from the observed anomalies. The range of the control run decadal variances is from 0.016 through 0.078 $^{\circ}C^2$. The decadal variances of the observed residuals derived from the ERSSTv4, HadCRUT4v3, and HadISSTv1.1 are 0.032, 0.037, and 0.054 $^{\circ}C^2$,

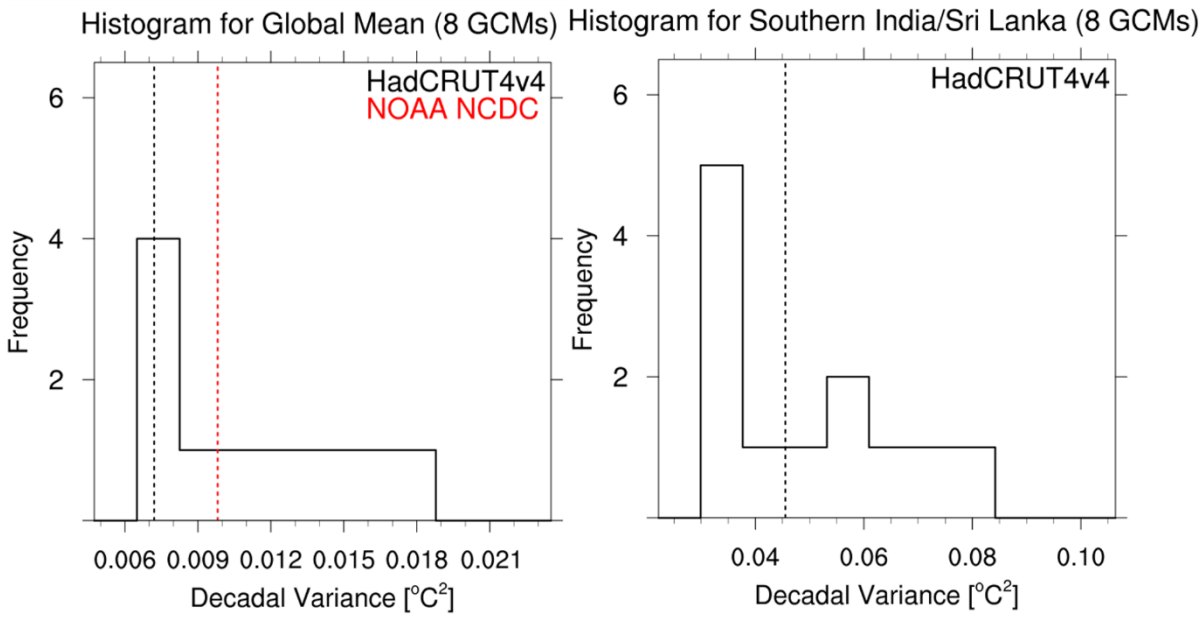
28 respectively, which were overestimated by roughly half of the models. The decadal variances
29 of the observed residuals and the control run decadal variances from the eight GCMs over the
30 globe and Southern India/Sri Lanka are represented in Supplementary Figure 2.

31 3. Uncertainties in observed temperatures over Southern India/Sri Lanka

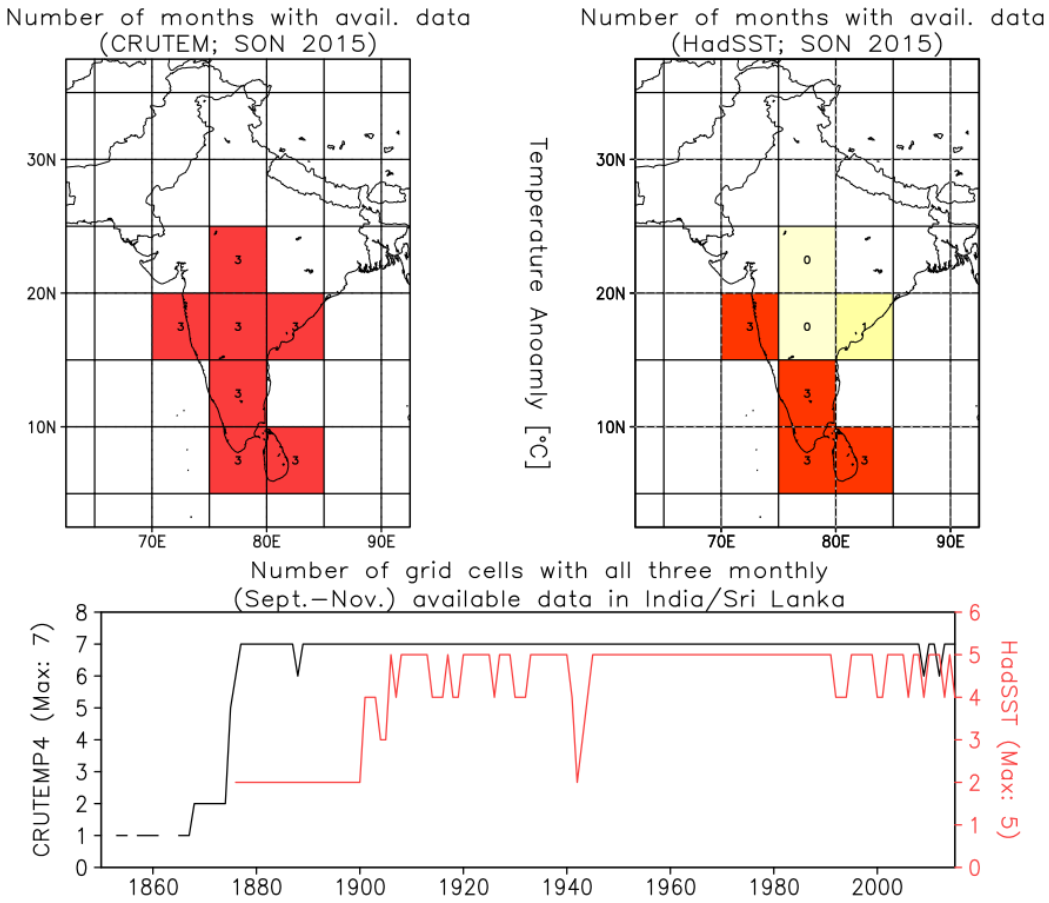
32 To address the HadCRUT4v4 temperature data uncertainties over Southern India/Sri
33 Lanka, we plotted the number of months with available observed data in 2015 (SON; the
34 maximum number is 3) over Southern India/Sri Lanka from the CRUTEMP4.4.0 and
35 HadSST3.1.1. data sets (Fig. S. 3). Also, we plotted the annual time series of the total
36 numbers of grid cells with all three monthly available observations over the study region
37 from CRUTEMP4.4.0 (the maximum number of grid cells: 7) and from HadCRUT3.1.1 (the
38 maximum number of grid cells: 5), respectively.



Supplementary Figure 1 a): Annual time series of the Niño4 region from the HadCRUT4v3 (black thick line), ERSSTv4 (red line), HadISSTv1.1 (blue line) datasets. Gray bars represent annual time series of fractional area with available data over the Niño4 region. b): Histogram of the control run decadal variances from the 23 CMIP5 climate models. The dotted lines depict the observed decadal variances from the HadCRUT4v3 (black), ERSSTv4 (red), and HadISSTv1.1 (blue).



Supplementary Figure 2: Histograms of the observed and control run global mean (left) and Southern India/Sri Lanka (right) decadal variances for eight individual models.



Supplementary Figure 3: top: Annual time series of the number of months with available observed data in 2015 (SON; the maximum number is 3) over Southern India/Sri Lanka. bottom: Annual time series of the total numbers of grid cells with all three monthly available observations over Southern India/Sri Lanka.

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